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THE USE OF A HEAT-TREATED 14% CHROMIUM STAINLESS STEEL TO PRODUCE LARGE-SCALE AND SMALL-SCALE TORQUE SENSORS

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We have produced a large scale (0.75 inch) and a small scale (0.25 inch) torque sensor from type ESR-420 stainless steel for industrial torque transfer or small scale medical applications by appropriately polarizing two adjacent sections of the shafts with oppositely directed circumferential magnetization. The resultant field signal, found to be linear with applied torque up to 15 N-m, emanated from the domain wall formed between the two regions and was easily detected with a Gaussmeter. A two-step heat treatment, consisting of a rapid quench to room temperature from 1038°C, followed by a slow 3-day cool from 871°C to restore desired magnetic and mechanical properties, was applied to the samples to enhance performance. The torque-load sensitivity (field signal in μG per unit applied shear stress in lb/in^2 or psi) was found to be remarkably linear and as high as 237 μG/psi, with excellent re-zeroing capability, making it an ideal candidate for the small-scale applications where weak signals are usually a plaguing problem. Simultaneously, the magnetic hysteresis properties of the samples were studied prior and subsequent to the heat treatments. The axial coercive force was found to remain consistently low around 5-6 Oe throughout heat treatment, in correspondence with the large sensitivity values, while the circumferential coercive force remained around 25-27 Oe, which is sufficient to guarantee integrity of the magnetically polarized regions comprising the sensor at both scale levels.